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National Aeronautics and Space Administration
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ST-SP-10599

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SUMMARY

Photographs and the spectrum of the Sun were obtained in the shortwave ultraviolet and soft X-ray regions of the spectrum on 20 September and 1 October 1965 with the help of an apparatus installed on two geophysical rockets having attained the height of nearly 500 km.

The photographs and the Sun's spectrum obtained on 1 October from 03 h 59 m 20 sec. to 04 h. 05 m.10 sec. U.T. encompassed the concluding stage of an optical chromospheric flare and the initial stage of an X-ray flare. The latter took place in the region of the corona not having visible perturbations.

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* *

The results expounded here on the obtaining of photographs and a spectrum of the Sun in the region 9.5 – 200 Å, respectively on 20 September and 1 October 1965, are only preliminary. However, in the course of the last launching, the shortwave image and the spectrum of the Sun were apparently obtained for the first time in the course of an X-ray flare.

The apparatus consisted in both cases of a camerae-obscurae block and a spectrograph disposed over a tracking system that oriented the device toward the Sun along two axes. The apparatus was placed in the rocket's instrument container, which was stabilized in space along three axes over the ascending as well as descending portions of the trajectory.

The photographs obtained on 20 September did not provide any substantially new results. Two bright regions are shown on them, which are disposed over calcium flocculi. – Amongst the number of photographs obtained on 1 October a few are reproduced in Fig.1. They are related to the time period from $03^h59^m20^s$ to $04^h05^m10^s U.T.$

(*) IZOBRAZHENIYE I SPEKTR SOLNTSA V OBLASTI 9.5 – 200 Å
To be published in the Proceedings of the VII COSPAR SYMP. VIENNA, 1966.

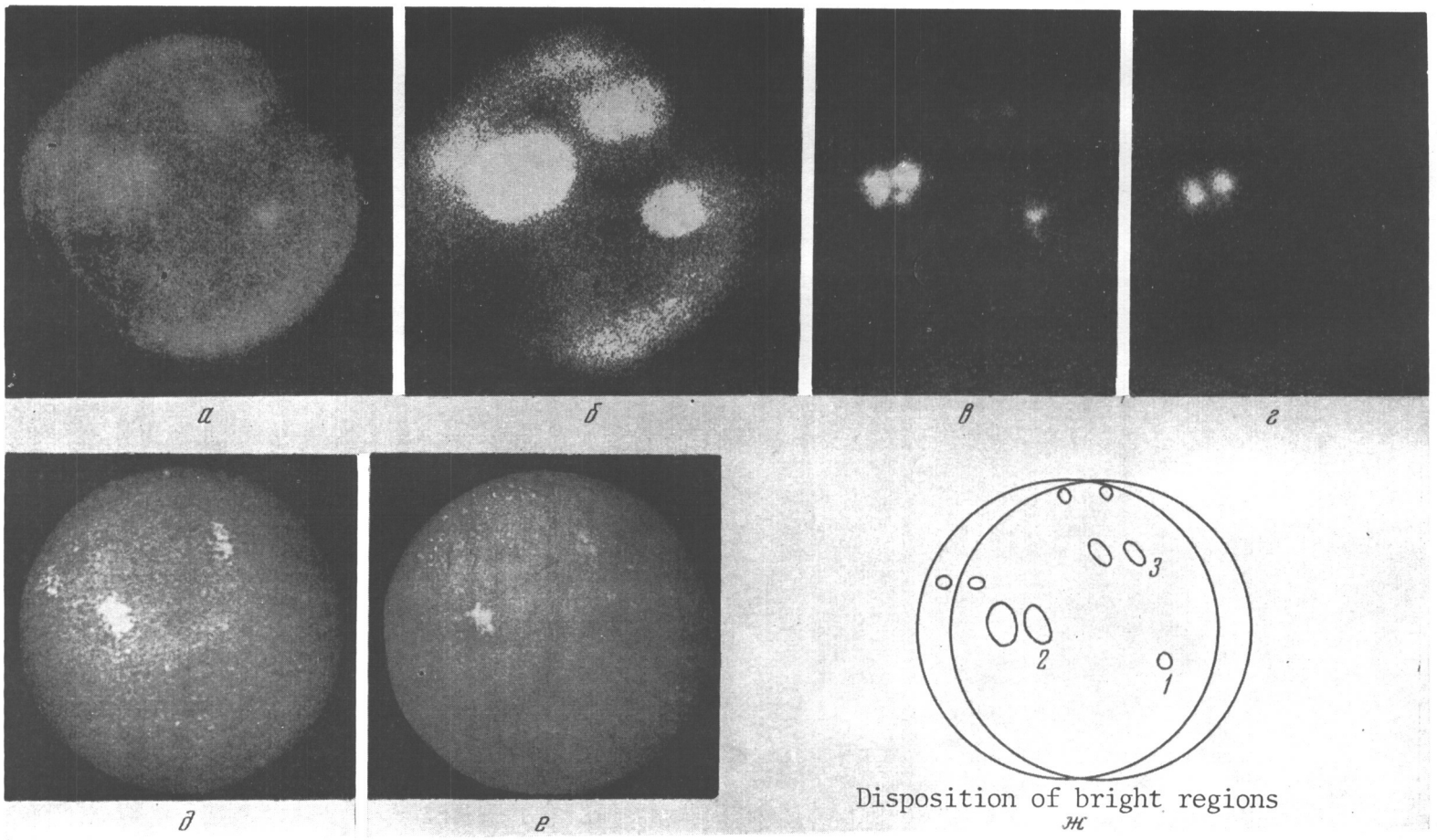

Fig.1. Photographs of the Sun obtained on 1 Oct.1965 with camera-obscura

Рис. 1. Фотографии Солнца, полученные с помощью камер-обскур 1.X 1965 г.:

а — фильтр Al, 1 *мкм*, разрешение 1′, $\lambda < 25$ Å, 170—200 Å; *б* — фильтр Al, 2 *мкм*, разрешение 5′, $\lambda < 20$ Å; *в* — фильтр Al, 2 *мкм*, разрешение 1′, $\lambda < 20$ Å; *г* — фильтр Be, 39 *мкм*, разрешение 1′, $\lambda < 10$ Å; *д* — фотография Солнца в линии KCa II 1.X 1965 г. 09^h45^m *U.T.*; *е* — фотография Солнца в H_α 1.X 1965 г. 09^h45^m *U.T.*; *ж* — схема расположения ярких областей

a) Al filter; ..resolution ... . д) Photograph of the Sun in the line K Ca... ... ...

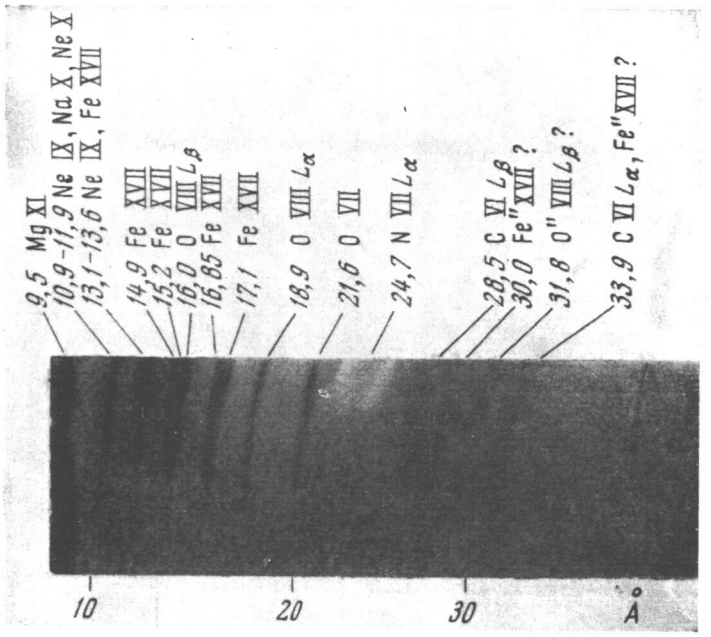

Рис. 2. Коротковолновый участок спектрограммы, полученный 1.X 1965 г.

Fig.2. Shortwave portion of the spectrogram of 1 October 1965

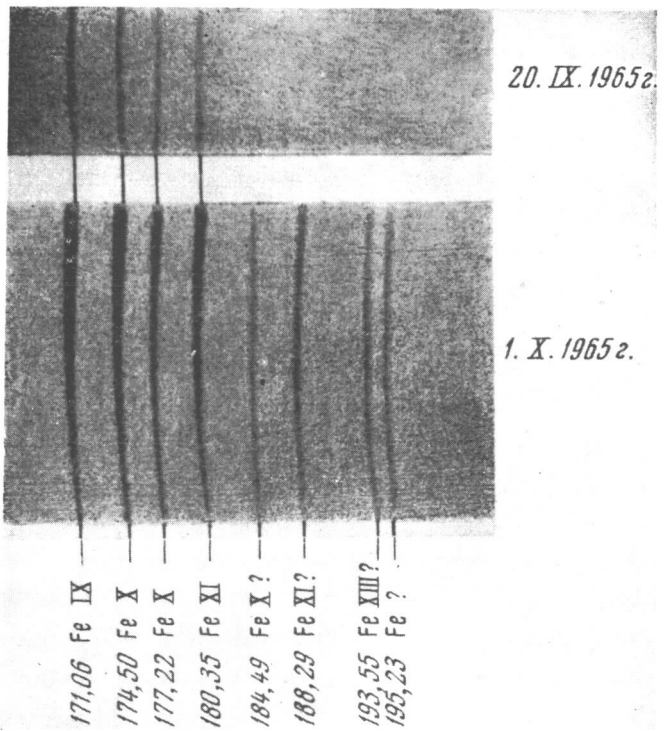

Fig.3. Longwave portiols of spectrograms obtained on 20 September and 1 October 1965

Рис. 3. Длинноволновые участки спектрограмм, полученные 20.IX и 1.X 1965 г.

Doubling of all details on the solar disk can be seen in the photographs, with the exception of the bright region 1. This is conditioned by the operating regime of the tracking system; analysis of telemetric readings has shown that the container with the devices performed in the horizontal plane an oscillating motion relative to a certain central position with period of a few seconds. The tracking system had a zone of insensitivity with width $\sim$ 1.5' along one axis; as the container moved to one side, the tracking system "released" the Sun by 1.5' at the outset, and then accurately followed the rotation of the container. During the last oscillations, at about 0405 hours UT the motion of the container changed: it began to rotate toward one side, the tracking system "losing" the Sun. Hence it follows that the bright region 1, devoid of doubling, arose in the Sun during the last container oscillation, that is, at about 0405 hours UT. It can be clearly seen on photograph 1,σ, and also on negatives of the remaining photographs, that the image of this region drifts beyond the cadre during the final turn of the container. Thus, we reach the conclusion that the bright region considered constitutes the image of the solar flare on the Sun having begun at about 0405 hours UT.

The estimates of the magnitude of the emission flux from this region are compiled in Table 1. The data obtained are in good agreement with the fluxes of X-ray radiation registered during the flare by the photoelectric method [2].

No active formations are seen in the photographs of the Sun in the lines H_α and K Ca II for 1 October 1965 in the region of X-ray flare appearance. Nor were observed any chromospheric flares in the Sun's region of interest to us. It should remarked, as this stems from the photoelectric measurements on satellites, that in the absence of optical flare X-ray flares appear rather often. Now we see for the first time that an X-ray flare emerged in the region of the corona devoid of visible perturbations.

The bright regions 2 and 3, visible in the photographs, correspond to the active formations seen in the lines H_α and K Ca II. A chromospheric flare of class 1, with maximum at 03043 hours and end at 0357 hours UT, began in region 2 at 0341 hours UT. Therefore, the very large fluxes of X-ray radiation in this region, compiled in Table 1, are caused by the flare. Still another, fairly small active region, adjacent to region 2, can be well seen in photograph 1,σ ; this region is not seen in photographs obtained with filters $\lambda < 15$ Å.

A diffraction grating with radius 1 m, 600 strokes/mm and gold plating was utilized in the spectrograph; for a 2° sliding angle the grating gave an energy concentration in first order in the region $\lambda \approx 60$ Å. The spectrograph's slot had the shape of a wedge, its height constituting 12 mm, with maximum width of 50 mkm. In order to suppress the scattered light of longwave radiation, a filter was installed ahead of the slot by the Tousey method [3]; this filter consisted of a nitrocellulose film of $\sim$1000 Å thickness with a superimposed Al-film 1500 Å thick. In the launching of 1 October 1965 the wider half of the slot in height was further concealed by a second such filter. The spectra were photographed on SG-5 film.

TABLE 1

X-RAY EMISSION FLUX FROM ACTIVE REGIONS IN THE SOLAR CORONA ON 20 SEP. AND 1 OCT. 1965
($erg/cm^2 \cdot sec$)

Date and Time of exposure	Emitting Region	$\lambda<25$ Å	$\lambda<2$Å	$\lambda=8+15$ Å	$\lambda<10$ Å	Annotations
20 September	Bright Region 1			$\sim 2\cdot10^{-4}$		
$03^h28^m50^s - 03^h38^m50^s$ U. T	Bright Region 2			$\sim 2\cdot10^{-4}$		
1 October	Bright Region 1	$\sim 2{,}6\cdot10^{-1}$	$\sim 1{,}75\cdot10^{-1}$	$\sim 5\cdot10^{-2}$	$\sim 2\cdot10^{-2}$	X-ray flare comm. at 0405 hours UT
$03^h59^m20^s - 04^h05^m10^s$ U. T	Bright Region 2	$>1\cdot10^{-1}$	$>1\cdot10^{-1}$	$>3\cdot10^{-2}$	$\sim 1{,}5\cdot10^{-2}$	Chrom. flare class 1 comm: 0341, end: 0357 hours UT
	Bright Region 3	$\sim 3\cdot10^{-3}$	$\sim 3\cdot10^{-3}$	$\sim 7\cdot10^{-4}$		
	Entire flux from unperturbed corona		$\sim 1{,}5\cdot10^{-2}$	$\sim 2\cdot10^{-3}$		

In the experiment of 20 September 1965 the shortwave end of the spectrogram was found to be somewhat defocused and blurred by the scattered light. In this spectrogram the lines are visible in the regions 21.6–72.3 Å and 170–195 Å. Visible in the spectrogram obtained on 1 October 1965 are the lines in the regions 9.5–50.6 Å and 170–181 Å. It should be noted that because of weak blackening of the lines in the shortwave region of the spectrum, the precision of wavelength measurements is small in both spectrograms, just about 0.05–0.15 Å. This hinders the identification of the lines.

The shortwave portion of the spectrogram of 1 October 1965 is brought out in Fig.2. Plotted here are the measured values of wavelengths and the possible identification of lines based upon ref. [4 - 6]. It may be seen on the original spectrogram that several lines are disposed in the segments 10.9–11.9 Å and 13.1–13.6 Å; their division was found to be quite difficult and this is why the identification has a very preliminary character. The emission flux for the line group λ = 10.9 ÷ 11.9 Å constitutes, according to a preliminary estimate, $\sim 5 \cdot 10^{-3}$ erg/cm^2·sec and for the line λ = 14.9 $\sim 10^{-2}$ erg/cm^2·sec. The flux from the latter, registered in [4], constituted only $2 \cdot 10^{-4}$ erg/cm^2·sec. This is evidence that the shortest wave lines in the spectrogram of 1 October possibly characterize rhe spectrum of the flare having taken place in the active region 2 (Fig.1); the magnitude of the emission flux in the lines agrees well with the flux from that region registered by camera-obscura. It should be noted that the lines shorter than 13.7 Å in the spectrum of the Sun are observed at first; their wavelengths and identification must be corroborated by additional experiments. The wavelengths and the identification of the remaining lines in the shortwave region are in good agreement with the data of the above-mentioned references.

We brought out in Fig.3 the spectra in the longwave region; their measured wavelengths and line identifications also agree well with the data available in literature [7 - 9]; four of the longest wave lines are still unidentified.

The lines brought out in Fig.3 provide a fundamental contribution to Sun's image represented in Fig.1,a. The lines are excited in the intermediate region between the chromosphere and the corona; the brightening toward the limb, seen in the photograph, is evidence of the transparency of that region.

***** T H E E N D *****

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VOLT TECHNICAL CORPORATION
1145 19th St.NW
WASHINGTON D.C. 20036.
Tel: 223-6700; 223-4930.

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